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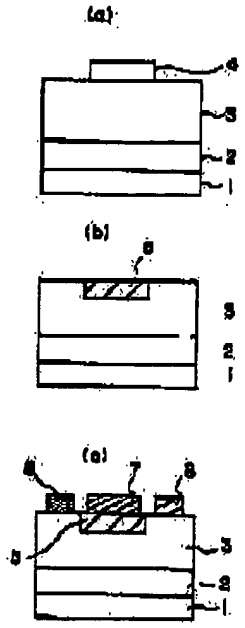
(71)Applicant : NEC CORP
(72)Inventor : KURAMOTO MASARU
IWATA HIROSHI

(54) II-VI COMPOUND SEMICONDUCTOR DEVICE AND MANUFACTURE THEREOF

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a manufacturing method with which a II-IV compound semiconductor device, having a high resistance layer of current constriction structure containing a II-IV compound semiconductor with which constriction of current can be measured, can be manufactured at a small number of processes.
SOLUTION: In this MISFET, after an i-ZnSe layer 2 and an n-ZnSe layer 3 have been grown successively on an i-GaAs substrate 1 by an MBE method, Cu is vacuum-deposited on the n-ZnSe layer 3, and a Cu layer 4 of specific width is formed using photolithographic technique. Then, a high resistance layer 5 is buried in the n-ZnSe layer 3 by annealing a wafer at 200° C in a nitrogen atmosphere as a high resistance layer forming process and by diffusing the Cu layer 4 on then-ZnSe layer 3. Besides, as a circuit forming process, a drain electrode 6, a gate electrode 7 and a source electrode 8 are formed on the n-ZnSe layer 3, including the surface of the high resistance layer 5.



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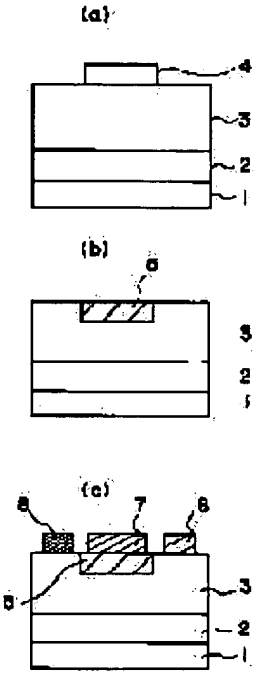


(57)Abstract:

PROBLEM TO BE SOLVED: To provide a manufacturing method with which a II-IV compound semiconductor device, having a high resistance layer of current constriction structure containing a II-IV compound semiconductor with which constriction of current can be measured, can be manufactured at a small number of processes.

SOLUTION: In this MISFET, after an i-ZnSe layer 2 and an n-ZnSe layer 3 have been grown successively on an i-GaAs substrate 1 by an MBE method, Cu is vacuum-deposited on the n-ZnSe layer 3, and a Cu layer 4 of specific width is formed using photolithographic technique. Then, a high resistance layer 5 is buried in the n-ZnSe layer 3 by annealing a wafer at 200°C in a nitrogen atmosphere as a high resistance layer forming process and by diffusing the

Cu layer 4 on then-ZnSe layer 3. Besides, as a circuit forming process, a drain electrode 6, a gate electrode 7 and a source electrode 8 are formed on the n-ZnSe layer 3, including the surface of the high resistance layer 5.

CLAIMS

[Claim(s)]

[Claim 1]II-VI group semiconductor device which having a high resistance layer from which at least one of Cu(s), Ag, and Au(s) which are II-VI group semiconductor and IB metal is contacted and alloyed, and which it comprises, and producing as a circuit of business.

[Claim 2]A semiconductor laser which is a semiconductor laser belonging to the II-VI group semiconductor device according to claim 1, and is characterized by being provided so that said high resistance layer may constitute current stricture structure.

[Claim 3]A manufacturing method of II-VI group semiconductor device characterized by comprising the following.

A high resistance layer formation process which contacts and alloys at least one of Cu(s), Ag, and Au(s) which are IB metal, forms a high resistance layer in II-VI group semiconducting crystal, and is accomplished with II-VI group semiconductor device.

A circuit formation process of establishing a circuit of business in said II-VI group semiconductor device by

electrode formation.

【Claim 4】A manufacturing method of a semiconductor laser which is a manufacturing method of a semiconductor laser obtained by application of a manufacturing method of the II-VI group semiconductor device according to claim 3, and is characterized by forming said high resistance layer in said high resistance layer formation process so that current stricture structure may be accomplished.

DETAILED DESCRIPTION

【Detailed Description of the Invention】

【0001】

【Field of the Invention】This invention is applied mainly as a semiconductor laser, a photo detector, MISFET, HEMT, etc., and it relates to an II-VI group semiconductor device which has a high resistance layer which comprises IB metal and II-VI group semiconductor, and a manufacturing method for the same.

【0002】

【Description of the Prior Art】As art relevant to the current stricture structure in the semiconductor laser which is an example of this kind of II-VI group semiconductor device, conventionally, For example, what used polyimide for the semiconductor raw material and constituted profit waveguide type laser is mentioned as indicated in 1991 to 【APPLEDPHYSICS LETTER / 1272 pages of the 59th volume】 of publication. As indicated as other

pertinent arts in [ELECTRONICS LETTERS / 568 pages of the 30th volume], and the same year of publication in 1994 to [APPLED PHYSICS LETTER / 2315 pages of the 63rd volume] of publication, Etching removal of a cap layer or the cladding layer is carried out to stripe shape, and what embedded by embedding a high resistance material and ZnS there and forming current stricture structure in it, and constituted the mold semiconductor laser is mentioned.

[0003]Incidentally, as example of another of the structural art relevant to a semiconductor laser, a semiconductor laser device indicated by JP,63-166284,A, for example, a manufacturing method for the same, etc. are mentioned.

[0004]

[Problem(s) to be Solved by the Invention]Since current spreads near an active layer in the case of the profit waveguide type laser mentioned above, there is a problem that strangulation of current cannot fully be measured as current stricture structure.

[0005]In the case of an embedding type semiconductor laser, in order to etch and embed a semiconductor laser part, a routing counter increases, and also there is a problem that exact eye doubling of a mask is required and fertilization is difficult.

[0006]It was made that this invention should solve such a problem, and the technical technical problem is in providing II-VI group semiconductor device which has a high resistance layer of the current stricture structure containing II-VI group semiconductor which can fully

measure strangulation of current, and the manufacturing method which can produce it simple with a small routing counter.

[0007]

[Means for Solving the Problem]According to this invention, II-VI group semiconductor device which has a high resistance layer from which at least one of Cu(s), Ag, and Au(s) which are II-VI group semiconductor and IB metal is contacted and alloyed, and which it comprises, and was produced as a circuit of business is obtained.

[0008]According to this invention, it is a semiconductor laser belonging to the above-mentioned II-VI group semiconductor device, and a semiconductor laser provided so that a high resistance layer might constitute current stricture structure is obtained.

[0009]A high resistance layer formation process which contacts and alloys at least one of Cu(s), Ag, and Au(s) which are IB metal, forms a high resistance layer in II-VI group semiconducting crystal, and is accomplished with II-VI group semiconductor device on the other hand according to this invention, A manufacturing method of II-VI group semiconductor device which includes a circuit formation process of providing a circuit of business by electrode formation in II-VI group semiconductor device is obtained.

[0010]According to this invention, it is a manufacturing method of a semiconductor laser obtained by application of a manufacturing method of II-VI group semiconductor device, and a manufacturing method of a semiconductor

laser which forms a high resistance layer so that current stricture structure may be accomplished is obtained with a high resistance layer formation process.

[0011]

[Function]Generally, II-VI group semiconducting crystal and IB metal (Cu, Ag, Au) are rich in reactivity, and are easily alloyed by low-temperature heat treatment. Since many lattice defects are formed, it becomes the alloyed high resistance layer which II-VI group semiconductor device of this invention has with high resistance. Since the field in which this high resistance layer is formed is restricted to the field which IB metal diffuses, it can form a high resistance layer field by arbitrary patterns by carrying out pattern formation of the IB metal. The reactivity to II-VI group semiconductor of IB metal has strongest Cu, and since it becomes small in order of Ag and Au, proper use of ****** Cu, Ag, and Au is made as for it to the temperature needed by the kind and its manufacturing process as an II-VI group semiconductor device.

[0012]

[Embodiment of the Invention]An example is given to below and an II-VI group semiconductor device of this invention and a manufacturing method for the same are explained in detail with reference to drawings.

[0013]First, the outline of II-VI group semiconductor device of this invention is explained briefly. This II-VI group semiconductor device has a high resistance layer which at least one of Cu(s), Ag, and Au(s) which are II-VI

group semiconductor and IB metal is contacted and alloyed, and changes, and is produced as a circuit of business. Although the semiconductor laser was mentioned as an example of II-VI group semiconductor device here, with the semiconductor laser, it was provided so that a high resistance layer might constitute current stricture structure.

[0014]When manufacturing such an II-VI group semiconductor device, as the manufacturing method, The high resistance layer formation process which contacts and alloys at least one of Cu(s), Ag, and Au(s) which are IB metal, forms a high resistance layer in II-VI group semiconducting crystal, and is accomplished with II-VI group semiconductor device, What is necessary is just to carry out the circuit formation process of establishing the circuit of business in II-VI group semiconductor device by electrode formation. What is necessary is just to form a high resistance layer with a high resistance layer formation process as the manufacturing method so that current stricture structure may be accomplished when manufacturing a semiconductor laser as an II-VI group semiconductor device especially.

[0015]Then, the following gives some examples and explains the manufacturing method of II-VI group semiconductor device concretely.

[0016][Example 1] In Example 1, MISFET which is an electron device as an II-VI group semiconductor device was manufactured. It is what was shown in order that drawing 1 might explain the manufacturing method of MISFET which

is an electron device concerning Example 1 of this invention, The thing about a side sectional view [in / in the figure (a) / the first half process of the manufacturing process], the thing about a side sectional view [in / in the figure (b) / the middle process of the manufacturing process], and the figure (c) are related with the side sectional view in the second-half process of the manufacturing process.

[0017]Here, as first shown in drawing 1 (a), on i-GaAs substrate 1 by an MBE technique 2-micrometer-thick i-ZnSe layer 2, After growing 200-nm-thick n-ZnSe layer 3 epitaxially in this order, providing it, and vapor-depositing 30-nm-thick Cu on n-ZnSe layer 3 with vacuum deposition, 1.5-micrometer-wide Cu layer 4 was formed with photolithography technique.

[0018]Next, as a high resistance layer formation process, by annealing this wafer under 200 ** temperature conditions among a nitrogen atmosphere, Cu layer 4 which suited on n-ZnSe layer 3 was diffused, and as shown in drawing 1 (b), burial formation of the high resistance layer 5 was carried out into n-ZnSe layer 3.

[0019]As gold was vapor-deposited as a circuit formation process on n-ZnSe layer 3 including the high resistance layer 5 top and it was shown in drawing 1 (c), the drain electrode 6, the gate electrode 7, and the source electrode 8 were formed, and MISFET was produced.

[0020]In this MISFET, if voltage is impressed between the drain electrode 6 and the source electrode 8, current will flow, and when the voltage of the gate electrode 7 changes,

the FET operation by that current change is obtained.

[0021]Although this Example 1 explained the case where MISFET was produced as an electron device, even if it is semiconductor devices, such as HEMT, it is producible similarly. Although Example 1 explained the case where ZnSe was used as a semiconductor raw material which accomplishes each class, it replaces with this, for example, it may be made to use ZnSSe, MgZnSSe, etc. or to carry out lamination using ZnCdSe etc. to an InP substrate top. Although Example 1 explained the case where Cu was used as an IB metallic material, at least one of Ag and the Au(s) may be further added in addition to this, and it may alloy, or Ag and Au may be substituted for Cu.

[0022][Example 2] In Example 2, the photo detector was manufactured as an II-VI group semiconductor device. It is what was shown in order that drawing 2 might explain the manufacturing method of the photo detector concerning Example 2 of this invention, The thing about a side sectional view [in / in the figure (a) / the first half process of the manufacturing process], the thing about a side sectional view [in / in the figure (b) / the middle process of the manufacturing process], and the figure (c) are related with the side sectional view in the second-half process of the manufacturing process.

[0023]1-micrometer-thick p-ZnSe layer [here / MBE technique / carrier density / in $1\times10^{18}/cm^3$] 10 on p-GaAs substrate 9 as first shown in drawing 2 (a), 3-micrometer-thick p^--ZnSe layer [carrier density / in $5\times10^{15}/cm^3$] 11, After carrier density grows

1-micrometer-thick n-ZnSe layer 12 epitaxially in this order and provides it by $1 \times 10^{18}/cm^3$. After vapor-depositing Ag on n-ZnSe layer 12 with the vacuum deposition method, pattern formation of Ag layer 13 which has a window 300 micrometers in inside diameter with photolithography technique was carried out.

[0024]Next, as a high resistance layer formation process, by annealing this wafer under 350 ** temperature conditions among a nitrogen atmosphere, Ag layer 13 which suited on n-ZnSe layer 12 was diffused, and as shown in drawing 2 (b), burial formation of the high resistance layer 14 was carried out into n-ZnSe layer 12.

[0025]As shown in drawing 2 (c), on the rear face of p-GaAs substrate 9, the AuGe electrode 16 was formed for Au electrode 15 which has a window 250 micrometers in inside diameter as a circuit formation process on n-ZnSe layer 12 including the high resistance layer 14 top, respectively, and the photo detector was produced.

[0026]In this photo detector, if reverse bias voltage is impressed and light is inputted, current will flow easily, and a photo detector with little dark current is obtained.

[0027]Although this Example 2 explained the case where ZnSe was used as a semiconductor raw material which accomplishes each class, it replaces with this, and it may be made to use ZnSSe, MgZnSSe, etc. or to carry out lamination using ZnCdSe etc. to an InP substrate top. Although the case where Ag was used as an IB metallic material was explained, at least one of Cu and the Au(s) may be further added in addition to this, and it may alloy,

or Cu and Au may be substituted for Ag.

[0028][Example 3] In Example 3, the semiconductor laser was manufactured as an II-VI group semiconductor device. It is what was shown in order that drawing 3 might explain the manufacturing method of the semiconductor laser concerning Example 3 of this invention, and the thing about a side sectional view [in / in the figure (a) / the first half process of the manufacturing process] and the figure (b) are related with the side sectional view in the second-half process of the manufacturing process.

[0029]The n type clad layer 18 to which the level of chlorine comprises 1.5 micrometers-thick chlorine dope $ZnO.92MgO.08SO.12SeO.88$ [in $5x10^{17}$] on n-GaAs substrate 17 by an MBE technique here as first shown in drawing 3 (a), The active layer 19 which comprises 0.1-micrometer-thick ZnSe, and the p type clad layer 20 to which nitrogen concentration changes from 1 micrometer-thick nitrogen dope $ZnO.92MgO.08SO.12SeO.88$ [in $1x10^{17}$], After nitrogen concentration grows epitaxially the contact layer 21 which comprises the 0.05-micrometer-thick nitrogen dope ZnSeTe in this order and provides it by $1x10^{18}$, On the contact layer 21 which etches into stripe shape, carries out pattern formation of Cu layer 22 after vapor-depositing 200-nm-thick Cu on the contact layer 21 with a vacuum deposition method, and also contains Cu layer 22, Au was vapor-deposited and Au electrode 23 was formed.

[0030]Next, by annealing this wafer under 200 ** temperature conditions among a nitrogen atmosphere as a

high resistance layer formation process, Cu layer 22 which suited on the contact layer 21 was diffused in the contact layer 21 and the p type clad layer 20, and it high-resistance-ized, and as shown in drawing 3 (b), into the contact layer 21 and the p type clad layer 20, burial formation of the high resistance layer 24 was carried out so that current stricture structure might be accomplished. In parallel with this time, In was vapor-deposited on the rear face of n-GaAs substrate 17 as a circuit formation process, the In electrode 25 was formed, and the semiconductor laser was produced.

[0031]In this semiconductor laser, it oscillates with 20 mA of current when supplying current, and the laser beam which controlled horizontal microfiche is obtained.

[0032]Incidentally, in annealing of 200 ** of temperature conditions, since only Cu layer 22 is spread and Au electrode 23 is not diffused, only the field which touched Cu layer 22 serves as high resistance. To formation of Au electrode 23, eye doubling of a mask is unnecessary, it is made easy and a semiconductor laser is obtained simple. The depth of the high resistance layer 24 is controllable by the thickness of Cu layer 22 to vapor-deposit.

[0033]Although this Example 3 explained the case where the thing of a ZnMgSSe system was used as a laser material, the thing of other II-VI group semiconductor material systems, such as not only this but a ZnMgCdSe system, may be used. Although Example 3 explained the case where n type GaAs was used as a substrate, the substrate by other materials, such as laser using a p type GaAs substrate and

a ZnSe substrate, may be used. Although Cu was used as an IB metallic material and the case where Au was used for an electrode material was explained, At least one of the IB metal (being Ag and Au in Cu Au Cu and Ag) of other may be added and alloyed, or other IB metal (being Ag and Au in Cu Au Cu and Ag) may be substituted [as opposed to / further / not only this but / Cu or Au] for Cu or Au, respectively.

[0034]

[Effect of the Invention]According to this invention, II-VI group semiconductor device which has a high resistance layer of the current stricture structure containing II-VI group semiconductor which can fully measure strangulation of current can be produced simple with a small routing counter as stated above. Since eye doubling of a mask becomes unnecessary at electrode formation and also it can control by thickness of IB metal layer which vapor-deposits the depth of a high resistance layer when manufacturing a semiconductor laser as an II-VI group semiconductor device especially, it is made easy and becomes producible simple.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1]It is what was shown in order to explain the manufacturing method of MISFET which is an electron device

concerning Example 1 of this invention, (a) is related with the thing about the side sectional view in the first half process of the manufacturing process, the thing about a side sectional view [in / in (b) / the middle process of the manufacturing process], and a side sectional view [in / in (c) / the second-half process of the manufacturing process].

[Drawing 2]It is what was shown in order to explain the manufacturing method of the photo detector concerning Example 2 of this invention, (a) is related with the thing about the side sectional view in the first half process of the manufacturing process, the thing about a side sectional view [in / in (b) / the middle process of the manufacturing process], and a side sectional view [in / in (c) / the second-half process of the manufacturing process].

[Drawing 3]It is what was shown in order to explain the manufacturing method of the semiconductor laser concerning Example 3 of this invention, and (a) is related with the thing about the side sectional view in the first half process of the manufacturing process, and a side sectional view [in / in (b) / the second-half process of the manufacturing process].

[Description of Notations]

1 i-GaAs substrate

2 i-ZnSe layer

3, a 12 n-ZnSe layer

4, 22 Cu layers

5, 14, and 24 High resistance layer

6 Drain electrode

7 Gate electrode

8 Source electrode

9 p-GaAs substrate

10 p-ZnSe layer

11 p^--ZnSe layer

13 Ag layer

15, 23 Au electrodes

16 AuGe electrode

17 n-GaAs substrate

18 n cladding layer

19 Active layer

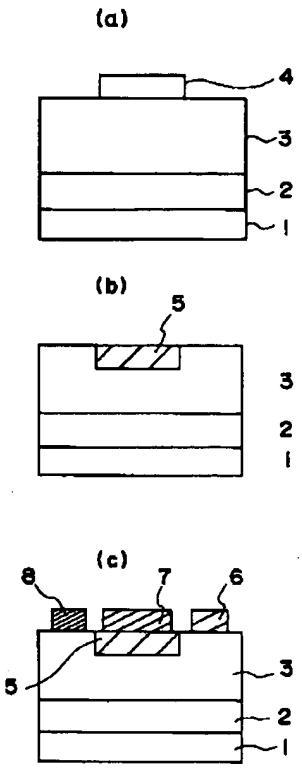
20 p cladding layer

21 p contact layer

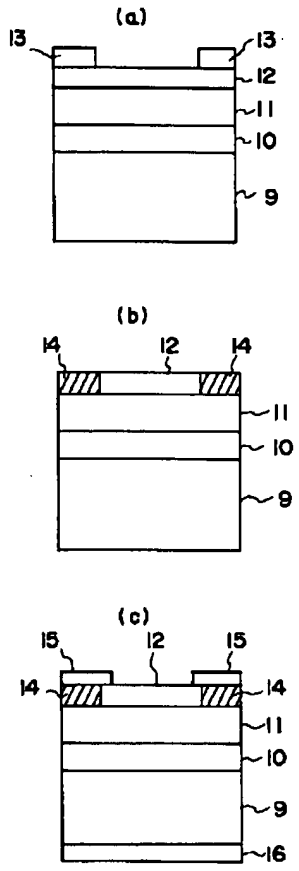
25 In electrode

DRAWINGS

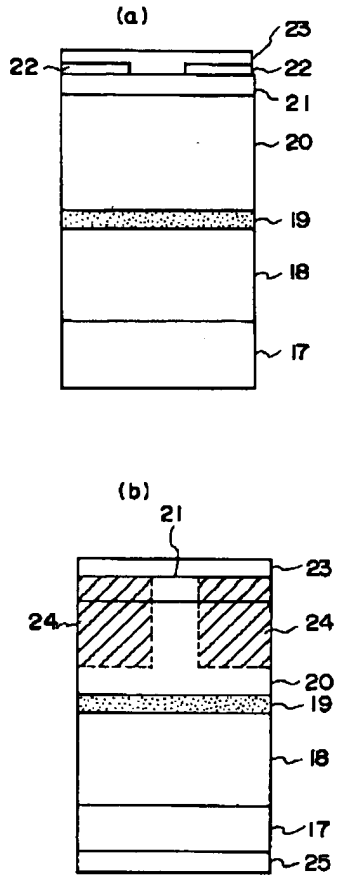
[Drawing 1]



[Drawing 2]



【Drawing 3】



[Translation done.]